



"I have found so much fun, with all these groups of internet people"

Peter Kirstein ARPANET international pioneer & european "father of the internet".

Early in the development of the Internet, he co-authored (with Vint Cerf) one of the most significant early technical papers on the *internet* concept. His research group at UCL played a significant role in the very earliest experimental internet work. He became Professor of Computer Communications Systems at UCL in 1970, and brought the first ARPANET node to Europe in 1973.



Interviewed Oct 31st, 2006 at the Kelvedon Hatch secret nuclear bunker (UK)

I was born in Berlin, Germany in June 20th, 1933. However, I left Germany when I was 3 years old. Fairly obvious reasons if you're at 3 and half years I wouldn't consider myself German, I would consider myself British. About my studies, I went to Cambridge, England from 1951 to 1954 but the British system was that you took your scholarship exams to University and then I had nine months or a year and nine months to spare, many people went to the ARMY then, but I actually went to California and spent 9 months in UCLA, then came back to finish my mathematics and engineering degree at Cambridge (in 1954). I had a couple (1951-1952) of summer jobs with the ARMY engineers at Los Angeles. So I had a UK-US background already then, and then I went back to the US and got my PhD in Electrical Engineering from Stanford in 1957. Then I went back to Europe initially for 1 year (but as I wanted to go skiing) I went to Geneva, stayed there during 4 years working for General Electric and then I went back to Britain in 1967, where I received a DSc from the former University of London Institute of Computer Science in 1970. I was appointed as a professor there in 1973. So up to then I had a lot of transatlantic experience and when I left General Electric, I wasn't actually replaced for the next 25 years, so I stayed as an external consultant for GE. So I kept having this European-US background; I think it's relevant to the whole of internet activities.



He was awarded¹ the ACM SIGCOMM Award and the IEEE Senior Award in 1999, and the Internet Society's Postel Award in 2003.

The problem with the NPL activity was that even it's quite true they had the first switch, it was only "one" switch in NPL; it never went through any distance at all; it was never connected even outside the NPL.

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Do you remember when you had your first contact with a computer?

No, I don't quite know when I do, but I don't remember if that was a computer. In 1951 when I first went to UCLA, I saw a one hundred meter long mechanical differential analyzer and I also saw the **SWAC**, the South West Automatic Computer, I only saw it that one at a distance. There were two computers built at roughly the same time, SWAC and the **SEAC** the South Eastern Automatic Computer.

So that's what I saw as my first one and when I got back to England, I also saw the **EDSAC**, which was a Cambridge computer. That was a powerful, real computer at that time, then I went to Stanford and that was the first computer I used, I think it was 19 words of storage, was the IBM 605. And that was the most powerful computer at Stanford in 1954, so that was the first one I used.

What was your first contact/experience with the ARPANET?

Sorry to be long in answering these things but I don't quite know how to describe my first contact. In 1965 or 66, I was visiting UCLA and first of all there was a graduate student sitting up on the roof there, somebody called **Vint Cerf**. There was an open space on the roof there, it was a flat roof and Professor **Jerry Estrin** described to me the network they were building. And the network at that stage, UCLA had three 6091, one was at the Electrical Engineering Department, the other at the Data Processing Center and the last one was at the medical school. Those three were going to be connected together

¹ Professor Peter Kirstein is widely regarded as the 'European father of the Internet' and, through his leadership in UCL Computer Science, he has placed UCL at the forefront of internet research for more than 30 years. He spent much of the 1960s working abroad. He is a Fellow of a number of professional bodies including the Royal Academy of Engineering and the British Computer Society and Fellow of the Institute of Electrical and Electronic Engineers (IEEE)

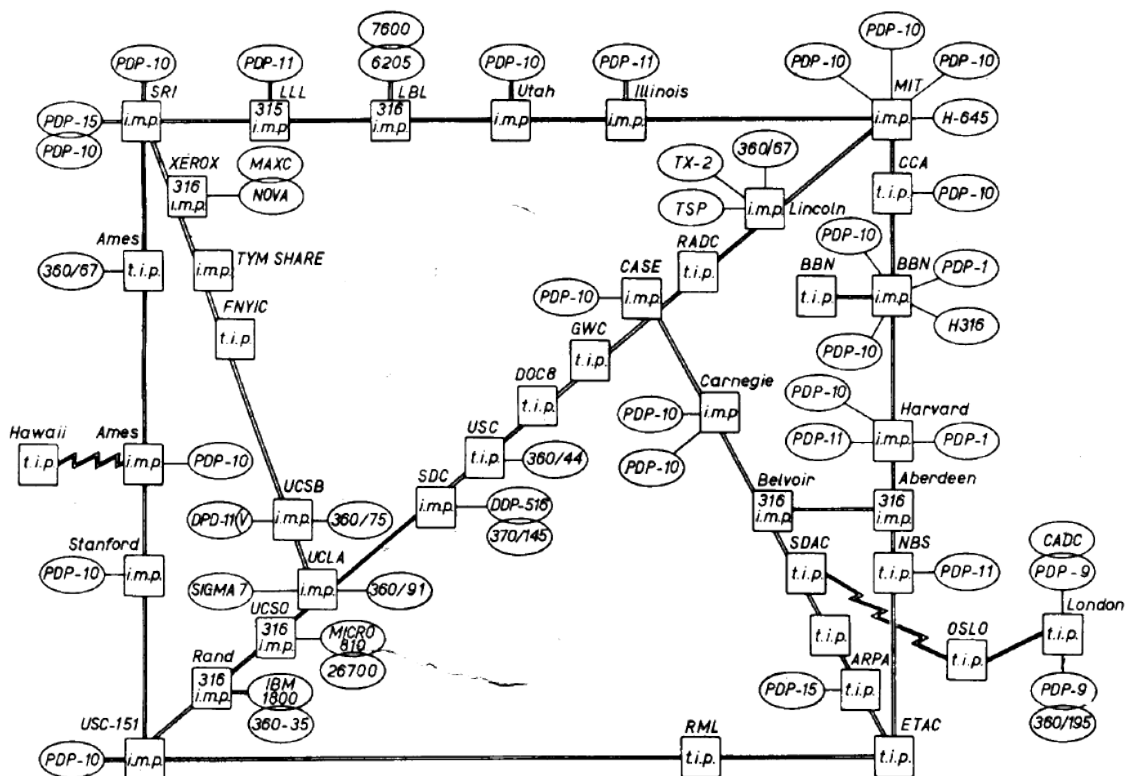
Public recognition includes a CBE (2003), a Lifetime Achievement Medal from the Royal Academy of Engineering (2006) and becoming a Distinguished Fellow of the British Computer Society (2004). Dr Kirstein was inducted into the US National Academy of Engineering as a foreign associate in 2009. He also received the Commander of the British Empire in 2003. Lifetime Achievement Medal of the Royal Academy, Honorary Fellow of University College London 2006



with an IBM 360-40 in Princeton and that was going to be a network experiment. And that was actually the first network I had seen and it probably spark of the idea of the ARPANET (few years later), from some sense, because it is for the first time you put a front end machine behind a host.

Later on I was following this developments, as since early 1970's I used to go every year to UCLA, I suddenly saw the beginning of the ARPANET, I kept bothering a gentleman by the name of **Bob Kahn** (at the time working for BBN) and kept asking him about modems and how you connect things and so on. He couldn't actually believe anything would happen out of it, I was very surprised when at the end it turned out yes, he had by that time left BBN and gone to DARPA. Bob Kahn was actually the systems designer of much of the ARPANET system. The actual building of the IMP was of course **Dave Walden** and **Frank Heart** and various other people, and from there you can find the rest from all the histories in this book, so I don't need to tell you the history.

But actually already, in October 1972, when there was that famous ARPANET demonstration conference in Washington DC, I was talking about the European Network situation so it has been deliberately then, complimentary to what was going on in the States, and that when I suggested to **Larry Roberts** (ARPANET architect) that we would do something different from anybody else in the world, we would connect computers remotely, which wasn't happening in the ARPANET because all they had was small computers (Digital PDP-9) and I was going to connect to the ATLAS computer in University of London computing center: the IBM 360/40 at that stage, which was some 70 miles away, and I was going to connect them: looking one way exactly like ARPA computers, with all the right protocols, and the other way exactly like an IBM front end, an IBM terminal or CDC terminal, that was new to them at the time and if you look at the early maps somewhere around October or November 1973, you will see the ARPANET terminates at UCL on my PDP-9 but the hosts are called the ATLAS computer center. Later on we added also the computer aided design center. So all those three were remote from me but from the US site, they looked alike as if they were ordinary hosts. We used IBM terminal protocols and in fact as early as October 1973, we have done it already; I gave a talk saying that they rather find that machine on the ARPANET.



September 1973. ARPA NETWORK logical map.

Somebody came up to me from their system staff afterwards and said "that was a very good talk you gave, however of course, it wasn't true, because we can not tell because we have never seen any sign of being on the ARPANET". I said: "that's exactly right, all you see is something that looks like an IBM terminal, which is attached to you, but the other way around, it has got the whole ARPANET around it". They were rather worried about that. That was part of my original proposal in 1971. It took about two years to get the whole thing agreed, I was trying to get some funding, which I never really got and it was nearly ruined at the beginning because **Larry Roberts** offered me an ARPANET Terminal (TIP²s) and I put that into a proposal to the British Science Research Council, they didn't believe me and the chairman of the Science Research Council wrote to the director of DARPA, requesting confirmation; the director of DARPA has heard nothing about this at all and so he asked Larry Roberts what was all this about, Larry didn't like it and got upset because before the director of DARPA, "he was going to do something as surprising as exporting the ARPA network to Europe"...

² TIP: Terminal Interface Processor. The first one was deployed in Sept. 1971, enabling individual computer terminals to dial directly into the ARPANET thereby greatly increasing the ease of network connections (compared to their bigger brothers the IMPs) and leading to significant growth. Later they were called gateways and nowadays we call them routers.



Later I got to know **Steve Lukasik** who was (from 1970 to 1975) the Director of the whole DARPA and he approved the idea. I was writing the proposal to a small department, pretty far down, but it was surprisingly enough important that it went all the way up to the director (the equivalent to the National Science Foundation) who then wrote to the director of ARPA for confirmations. At this stage I was also trying to get approval from the Department of trade and Industry. and so I wrote to ... who I knew very well and waiting reply for 8 months and when they finally replied, they said they were looking at it very carefully. I was only asking for 20 or 30 thousand pounds, I think and they decided that it was much worthwhile to spend two weeks on a visit to the ARPANET in the US than to do it ourselves.

I am not sure if this is answering your *first contact* with the ARPANET question.

So, I didn't get approved at all, there were no objections from Steve Lukasik and I got 5.000 UK pounds from **Donald Davies** (from the British National Physics Laboratory). That was the most Donald Davies was allowed to do from his own funds and it arrived so I could get started but then my computer arrived between 1971 (when the whole thing had started to be negotiated) and 1973 when the computer arrived, the TIP was duly shipped in July 1973, its value was somewhere around 50.000 US dollars and that was the value declared but between 1971 and 1973 the British have introduced something called value added Tax (VAT) and that was 10 percent roughly of the value. So, when this TIP arrived, I've got a bill at the same time for 5.000 UK pounds in order to import the TIP, well that was my tutelage money. So what I did was I under protest said I would appeal but on the mean time I should have it. So I appealed and I appealed for about a year and half and that was then turned down by the treasury and I was told that it was a political issue, couldn't do anything about it. So I then wrote to the treasury and said "alright, I would export this TIP" and then I would re import it under the **ap act** from the US to UK. They didn't like the sound of this, by this time I already had contracts from 6 ministries. I was then called in to a very high level of the treasury and said "what you're doing is of no interest to the department of health?" "No sir, although I had a contract from them" "It is of no interest to the British Library?" "No, although I had a contract from them" "No interest to department of education and science?" "No, and they went on to the ministry of defense and so on", then they said:

The treasury department to Peter Kirstein: "well, in that case, we hereby give you permission, since it is of no interest to any of British ministries and only to United States, you have permission to import this and any subsequent equipment free of tax and duties".



For the next 10 years, this small research group was on the end of that time running a complete national service with computers in the Ministry of Defense.

After a year we started with ARPANET we heard about this new satellite network called SATNET, so I had some more computers for SATNET we put them on the defense research laboratories so they had more equipments. Bob Kahn actually started SATNET more or less in 1973 giving the contract to BBN but it couldn't happen in Europe until first of all the Goonhilly Downs³ in UK and Tanum in Norway had been taking care of properly and then it had to involve some offices, so he was discussing with three other countries⁴, Germany, Italy and Canada.

About that time, first of all, the British had already a centralized research network based on its large IBM-360 (by that time 360/95 or 361/95) and they had a centralized IBM network.

At the same time there were two other centralized networks, one was based on CDC in London and the other was ATLAS at the Computer Design Center in Cambridge. I connected all them together; the CDC one didn't work very well because they had the wrong sort of protocols, we couldn't do anything very interactive but the others were all on for quite a while and in the meantime the networks around them grew and I had to change and convert what we were doing to make it still stay transparent to the US.

On **July 25th, 1973**, the University College London (UCL) node of the ARPANET passed its first data packets between London and the Information Sciences Institute in California, USA. This is believed to be the first instance of an international heterogeneous computer network;

Of course, we had other problems earlier and that was when **Jon Postel** was very annoyed with me because the British department of

³ Vint Cerf wrote this detailed explanation when asked on this topic: Before UCL was put up on the ARPANET, only the NORSAR (Norway) facility was connected by satellite. Bob Kahn worked out an arrangement to increase the total capacity of the system and also arranged for UCL to be connected to the ARPANET. Initially NORSAR was connected to the ARPANET by a dedicated satellite connection. The capacity was increased and UCL was connected to NORSAR by land line. The satellite ground station was at Tanum, Sweden. Later, the Packet Satellite system was fielded via INTELSAT IVA and UCL was connected to the SATNET and the land line to NORSAR was removed. UCL was connected to the SATNET through a ground station at Goonhilly Downs, (UK). NORSAR/NDRE was re-connected to the ARPANET by way of SATNET which also used a ground station at Tanum (SE).

⁴ Germany and Italy were no particular problem; they happened but they never did anything because they never had the infrastructure and there were too many problems with what they were allowed to do. Norway never went very far for the same sort of reasons and Canada never got started for a very interesting reason. In Canada, it was Bell Norton who was interested but Bell Norton was responsible for meetings with USA. The satellite were under, whatever it was, the agency part of UQC and they were not going to give up their rights to satellite but they had no rights to connect to USA and therefore since those two couldn't agree, Canada could never join. But Comsat was, so we had them and also some smaller stations at the time.



trade in the late 1920's started talking about car registration and they decided that the British country code was **.GB**.

When I said we were the first domain name (outside the US) and I had to choose nothing better and chose UK because that was Britain and Northern Ireland, so I just chose .UK. Around 1986 Jon Postel was trying to put some order into things and said: "*Peter, you've got to choose, you can't have two and GB is the proper⁵ one, so you've got to choose whether you would use GB or UK*". There was a 4 or 5 years period in which we were discussing backward and forward, the British rejected on principle being dictated to by the Americans on this, you can imagine all the rest. I at one stage guaranteed to Jon Postel that within one week of his moving all of the United States onto the .US top level domain, I would move all of Britain onto .UK. But he didn't think this was very funny, perhaps that should be one of my anecdotes. It was even worse; the British, one of them even wanted to have **.UKUS** to show that one was using ARPA's internet protocols and then **.GB** for the one that used the OSI protocols. That was one of the proposals, but I refused that one; I said that was just not the way things are supposed to be done.

The other thing where we were first is to use the internet protocols for service⁶;

TCP: the first three implementations:

Daily traffic on the ARPANET exceeds 3 million packets and DARPA funds three contracts: one at Stanford, California (with **Vint Cerf** and his students), another at BBN, Boston (with **Ray Tomlinson** and **Bob Thomas**) and the other to us at UCL to develop and implement what at the time was called the *Kahn-Cerf TCP protocol*. The Stanford team produced the detailed specification and within about a year we had three independent implementations of TCP that could interoperate.

So UK was the first domain name; I knew nothing about GB until 3 or 4 years later. It may still exist, I am not sure if the MoD⁷ decided to use it.

⁵ As for 2011 only one sub domain is still registered in **.GB** (ISO 3166-1 official code for the United Kingdom) and no new registrations are being accepted for it. Sites in the UK use **.UK** as their country code Top Level Domain (ccTLD).

⁶ As my PDP-9 (which I bought in 1968) was getting rather **longer tubes** in 1969 and I had to get rid of them; there's no point in putting in NCP⁷ again, so I started putting in this new internet protocols (TCP) and started running services with them. After 12 years it probably is a long time for a communication computer with at most 32-thousand words which has to do all these works about changing protocols and reversing domain hierarchical order of everything. Anyway, so we tried to go into service somewhere around 1981, well before the NCP to TCP cut over (January 1st 1983) and we complained because it was just not ready for service, but we had to run a national service on it and is within when they were started on the service, the US started to understand why we were complaining.

⁷ MoD: stands for the Ministry of Defense in the UK.



One of the whole secrets to put the whole thing working was that I set up a Political Governing Committee on the budget, which was formed by someone from the British post office telecomm; it had somebody from the academic side, different people, different times. Around about 1974 I wrote to ministry of defense because this whole thing might have been collapsing and they sent the chief of guided missile to talk to me and they decided to give me a contract and various people, for instance **John Taylor** was the first person on my governing committee from the ministry of defense; he later became the director of the research council. And there was always somebody from defense and they took a guess around about 1984/5 when this first question of GB came out, that the GB would be the one that wins the battle, not UK, so he moved some of the ministry defense people on to GB but he couldn't move it back so he got frozen for a while...

Making things compatible both sides:

First of all, the whole principle was based on when one could or couldn't manage these major differences between the two sides, so for instance, file transfer in the ARPANET was interactive; in the British system, (so called colored books) it was a batch link; how do you give reasonable responses when you are trying to go between such things? We were very deeply involved in all the British systems which all were based on what the telecom companies were doing at the time.

The standards were described at the so called *Colored Books*; we obviously participated in the formulation of those, particularly in the Grey book (about the email). It was a European project, yes, and a British one. The British really pushed the *Colored Books* themselves. To keep our connection and system working we had to be completely *colored book* compliant at one way and then completely ARPANET the other way. So what you could do and you couldn't do on that was already important.

The other think is we were heavily involved in SATNET and some of the voice activities at the time and we, actually we did some measurement because around about 1977 the British started putting in their own packet switch service⁸.

We were part of the SATNET experiments, but then somewhere around 1979, SATNET stopped being an experiment and the Germans, Norwegians and Italians, stopped participating; we ran SATNET as a service for the next six years and what we actually did was we ran SATNET for some of our traffic and for the International Packet Switch

⁸ First of all in 1977 it was called **EPSS**: Experimental Packet Switch Service then called **PSS** Packet Switch Service and later on changed to **IPSS** International Packet Switch Service.



Service. IPSS was based on X.25 protocols. We did some measurements on that for British Telecom and we also had traffic going one way or the other.

In your opinion, what are the key characteristics of Internet?

Well, I think one of the most important one is that you have a particular level at which interconnections are possible and that you can isolate things both above and below that particular level. That means you can have different network technologies below that level and different application technologies above that level. The fact that it is a universal value, gave one a lot of freedom in what one connects with and how one connects with.

The problem is the protocol isn't completely optimal, so as long as I remember, there has been attempts to break through the rigid levels and optimize things below or above and of course if one does, one is going to break this universality, but it will become more efficient, and we've had this dichotomy for as long as I remember; it is still there.

People are putting QoS (Quality of Service), signaling what you need for QoS, etc. That's always been; the key problem is that you had the capability of having the insulation and then you fill either above or below with various mechanism for guaranteeing quality of service or security or anything else. It is not a deadlock, I mean it works fairly well, it works better now than it used to; the reason that it works better than it used to is because we can now over engineer on bandwidth. It is interesting actually; one of my main projects now is concerned in introducing the internet satellite-based in few developing countries. We have limited bandwidth; 30 Mbps for the whole 2 regions; but we want Voice over IP and videoconference; one can do that by putting in the right Quality of Service (QoS) in the routers, we have time terminals, which should get priority and then those get priority and go faster.

We are technically able to do that. But on the other hand, that's very heavy work on the routers; so what I have ended up doing is overdesigning the bandwidth, to increase the quality, lowering routers' work.

I am a great believer in IPv6, which of course is touching it and by the way I think that will end up certainly happening. The main reason that it will make it happen is because so many of the newer protocols are being aligned for the IPv6 so sooner or later it will have to happen.



The other characteristic is the big scalability; I mean the fact it survived at all from the original experiments in 1975 to what happened to it in 2006, is really incredible. We always thought about doing one or two conversations over this thing but to actually have the level of real time traffic we now have, it was never imagined at all.

Then of course the next is the various application specific protocols, in particular of course, the web. I found it easy to adjust to the things that existed underneath, one thing which still needs working through is the fact that there are a number of different ways of doing security and that causes real problems...

And I don't see any sign of that being resolved. There are too many vested interests. VPN means you have one form of control by one set organization; you can mandate IPSEC but you're not going to have that done on the mobile side because they want to have security based on what they control; you have today from HP, where you could have some cards in the laptops, that's the security which the mobile telephone world would like better and the fact that you have so many different types is very unfortunate and yet they are all essentials. It's essential to have it somehow.

What do you consider the most important milestones in the development of the network?

- 1974 I think the first really important milestone was the concept by **Bob Kahn**, of having completely different networks, at some level in protocol, to work together. the internetting problem. Analyzing gateways that could work and we finally realized that in november of 1977 with the first three network experiment (ARPAnet, SATnet and packet radio PRnet working all together).

Vint Cerf and I wrote (the only joint paper we have ever written together) specifically analyzing gateways and different types of issues which could exist. He was my project officer⁹ in DARPA and I know that we gave reasonable value for the small contracts we had with them. So I think clearly, the concept of connecting networks was the first really important one.

⁹ You see I have always had on the one side these people I mentioned in UK, then a distinguished set of project officers from DARPA because I had DARPA contracts from 1973 to 2003. The list of people who were my project officers is a very distinct list; It was originally Larry Roberts, later it was Bob Kahn, it was Vint Cerf, Steve Crocker, then it was Paul Mockapetris, then it was Nicson John, Dyke Moon, Hillary Oman, all the people you know of one way or the other; they all have been my project officers and we were always trying to put a slightly different flavor on things.



- 1983 The next really important one was actually putting them to practice and that came in several ways; on the one side, the introduction of TCP/IP altogether as the official protocol and second of all, the growth in access networks, separate from the backbone networks, but still used similar protocol structures, very easily connected.
- 1984 Clearly the DNS, which was not off the TCP/IP was a huge advance.
- 1991 And then of course, the next biggest milestone was the winning of the protocol wars (TCP vs. the "official" OSI from ISO), which was an absolute and complete victory.
- The milestone that I am still waiting for is when there's a real acceptance in the US that IPv6 is a good idea. So far, all of the manufacturers are providing it but there is a very big lack of data. The real people pushing for it are the Chinese and the Japanese. In fact the main reason for Cisco went into it was because NTT request for tender, which requested that IPv6 be available and Cisco couldn't respond and Cisco doesn't like not being able to respond so immediately they put in an IPv6 program and virtually after the European pushed, all the American companies have implemented IPv6 on their products. But I mean it's completely standard on Microsoft, it's completely standard on your stack on Cisco, no difficulty at all. It's a chicken and egg, there's no immediate shortage of address in the United States. When the US run out of addresses this will be boosted and soon as the US cross over, other countries will cross over too and there's much greater shortage in Japan and China.

Why were we connected through Norway to the US-ARPANET?

1970: US starts receiving seismic data from NORSAR at Kjeller (Norway)

Seismic data went by cable from Norway to UK and then by satellite to US. ARPA's measuring nuclear testing was the initial reason to have that expensive international connection established.

1972: Seismic data goes to US through Tanum (Sweden) by Satellite.

1973: ARPANET connects by satellite to UCL, Royal Radar Norway & U.Hawaii.

1975: SATNET starts, direct US-UK link (Post Office & UCL) using Intelisat IV.

1977: Norwegian Defense Establishment link by satellite.



How did you contribute to the development of the Internet?

- First of all, not only having ARPANET to get international, which was just a quest **Larry Roberts** gave to me, but developing it into a real user community, first of all in Britain. If you compare what happened in UK with what happened in Norway, Italy and Germany, which all had satellite IMPs from ARPANET as well, they didn't develop in any of them and it didn't develop because in none of those three other countries, there was a slightest attempt to really bring in a user population and to track whatever was happening nationally, with what was happening in the US. It was being much opportunistic to think you could bring it in a minute and import straight into the European countries; you had to follow what was happening in Europe, track it and make things compatible to your country. And that I think was for a while an exchange novelty, it was not efficient, it was never going to scale, where the internet wanted to scale, but at least it made it possible to get a lot of experience of it and build up so when, they moved ARPANET over from NCP to TCP/IP (in January 1st 1983), we were at the decision to move over to the proper internet as it is today.
- I think the other thing that is very important about our contribution is that it kept the US side much more internationally minded. I don't know if you are aware, that in 1981 Vint Cerf started two different activities; the international collaboration board (ICB) for the defense and the international activity board (IAB). I ran the ICB from 1983 to about 2003. It was small, it only had some 6 or 8 defense departments (from Canada, the UK, Germany, the Netherlands, sometimes Norway, NATO and Denmark); that was small but at least it kept the international presence going on for these things. I killed it when DARPA said the thing could no longer attend if it was outside North America. I felt that it was no longer International enough, so there's no point in continuing it. It's not so much of cutting expenses, it's much more the US become more, that part of the US suddenly become much more introverted. I think the US has always been strong but sometimes it is being more international minded than other times and I think it is not its most international commitment, the moment it would like people to approve its policies, to collaborate with its policies, it would necessarily do other things.
- There are other things; we were very heavily involved in multimedia for a long time, and I think it was more linking some of these things, originally it was UK-US but later it became very much more European-US as well, so for instance I ran a whole series of multimedia European projects which had me collaborate with the US for quite a while. And I think in the project we made, we always did something a little bit different in attitude but not me in the major way, but we kept international presence for these things.



I would say developing it, bringing it was easy but to develop a user population is much more difficult.



During the personal interview at the Kelvedon Hatch secret nuclear bunker (UK). October 30th 2006.

Which was the first international connection to be established ?

In fact, it must have been the Norwegian one, they must have been days before than ours. The reason it must, although the original aim was to go by satellite to Goonhilly Downs (UK) and then by leased landline to Norway, by the time it happened (which is two years later), there was both the Tanum (Sweden) station and Goonhilly Downs station working and I believe the first one landed in. The IMPs came on the same time, which one was connected first? It was days, and I don't remember which one was first. I think one was by satellite and I think initially ours must have been first. There was a leased land line of 9.6 Kbits from the UK to Norway.

Why there was a connection from Washington to Norway?



The reason for having this is that there was something called the Nuclear Monitoring Research Office (a DARPA office), that was doing nuclear monitoring of its presence and that had 3 large sites: one in Alaska, one in Montana and one in Norway. And that had a 2.4 Kbps link, (from Norway to Washington DC).

Larry Roberts' initial idea was first of all to put the array of seismic¹⁰ sensors to the ARPANET, second was to do analysis and then increase the line speed to 64K from 9.6K.

That's how the whole thing started as far as I'm concerned. They had the line already except for the fact that they also needed to break the line internationally which wasn't allowed of course, and I had to find out about it. At those days, the idea of an academic asking the post office about a defense line, which was international... we had very strange things to do in the first few years of that. In July 1973 when the TIP (simplified version of an IMP) arrived and was installed, the communications line went from Washington D.C. to Goonhilly Downs' (UK) ground satellite base station and from there to London; in London it was less than an exchange and there it went by underwater cable to Norway.

That changed, by early 1975 when the SATNET project started and then we had satellite IMPs, both in Goonhilly Downs (UK) and in Tanum (SE) and in Germany.

The US did it because it didn't need to invest very much money. It was fairly easy just to put in an extra IMP; that wasn't very difficult, I mean they were deploying already 40 or 50 so putting one more next to one in Norway wasn't very difficult.

Who are some key people in the development of Internet, leaders or trendsetters?

First of all, quite clearly **Bob Kahn** and clearly **Vint Cerf**. **Jon Postel** for really keeping things going throughout in the very conscientious fashion. I think one of those who is under credited and under rated is **Dave Mills**; first of all, he was the first person who broke the monopoly of the gateways; he put together his own gateway called the *fuzzball*, where he was very good at that. The impact that we at one stage had 50 nodes (at the NSFnet) all doing different things, was itself another whole concept.

¹⁰ Steve Lukasik take on this: Today's Internet also can trace a major part of its early development to nuclear-test detection, as one of the major early applications of what then was called ARPANET was the transmission of seismic readings from various sensor stations around the world to a central analysis center. "We didn't really intend to wire the world together in the Internet, but that's what happened. We wired the seismic world together". Otherwise, it used to be you would mail in your tracings every day or two and it would take three weeks before all the data came in.



A person that belongs to government but did a lot of the early work at the UK is **Peter Higginson**; he did all the software. He left our group in 1976. I want to mention from the British side: **Steve Kille** (from the mail side); I would say those are really important.

Donald Davies of course but he is more from a theoretical point of view, rather than the internet point of view. Davies created the (the British National Physics Laboratory) NPL-network but the problem with the NPL-network was it was an *in house* network only; they were never able to get any funding at all for going outside NPL. EPSS¹¹ was different; The British post office decided that they would put in a packet switched service; initially internationally: EPSS. In order to do that, they would first put in an experimental network and that is what the EPSS was. I was under the strict instruction (and I suspect Davies was as well), that we had to provide access facilities to our networks through this and I did provide EPSS access through our PDP 9. The PDP 9 was running all protocols and nothing else, which is all they were there for. And so the EPSS had very little to do with Davies. What Davies was in particular concerned with, is something called the **EIN** (the European Informatics Network). He started up that network putting things in from NPL and getting others (particularly France with **Louis Pouzin's Cyclades-network**) and ISPRA (in Italy) among others, but that was not with NPL; NPL-network was never outside the NPL Laboratory.

We (at UCL) also used International packet switched services (from ARPANET), but Donald Davies was never able to do that; he was never able to get out and that was very sad.

Paul V. Mockapetris for creating in 1984 the Domain Name System (or DNS).

Another one extremely important but you don't hear much in these days, on the radio side is **Jim Matthys**. Also on the routing side, **Dave Walden** was always very important. I feel **Frank Heart** (BBN group leader) did a very good job on the switch (the IMP¹²) part, but it was not in very strategic portion of it, I don't think he was involved in the internet side of the thing at all, as far as I know. The IMP was a packet switch. I would say that **Ginny Strazisar** was fundamental, creating the first gateway. Somebody else who again is forgotten about but probably did more to revolutionize things than anybody else is **Leonard Bosack** (Cisco co-founder) they probably never mentioned him to you.

¹¹ EPSS: Enhanced Packet Switching Service. It was an experiment of the UK Post Office. Ferranti supplied the hardware and software. The handling of link control messages (acknowledgements and flow control) was different from that of most other networks and is not fully explained in the published literature.

¹² IMP: Stands for Interface Message Processor. Created at Bolt Beranek and Newman in 1969.



And by the way, we had the first Cisco router in Europe here at the UCL. Len was showing it in Paris and later drop it off in my place. But Len, again, made successful of this, by the time there was nobody who was competing with PROTEON (the router leader) but later on they died, whereas Len survived and grew.



And of course, **Bob Metcalfe**, because again, the Ethernet was absolutely vital and is now everywhere. One who could have had a strong impact but in the end didn't was **Maurice Wilkes**, (Cambridge UK) he didn't because even he came on what it could have been a good access technology, (the *token ring*) he didn't like to have standardization so it never really took off, so it wasn't a good access technology anymore. One of the really far thinking one is clearly **J.C.R. Licklider**; even I don't think he had much to do with the internet itself but he was thinking broadly around this.

You can't do anything without **Tim Berners-Lee** of course, but that's obvious. I think the first person who probably put more order onto the security side than anybody is **Steve Kent**. Steve is really a very intelligent person and he has followed this security issues from the beginning.

Len Kleinrock (UCLA) started a lot on making measurements respectable, but actually the person who I really liked from the measurement side is the gal in San Diego (CA), **Kimberly C. Claffy**, she is the one who has done more than anybody else in measurements lately and she ran a part of the measurement center at UCSD even she is not an old timer.

A couple of anecdotal situations

- So just to give you a simple example, the DNS came in around 1984. And the Americans decided the way how to do it: to say `kirstein.cs.ucl.ac.uk`. The British always know better, so they decided to do it `kirstein@uk.ac.cs.ucl` (just the opposite way). So I tried to persuade the British to change, they said "what right has a small research group to change what we do nationally?" so I tried to get ARPA to change getting this reply: "what right have you small foreign research group to change what we do in the United States?" so I therefore had to look at



every message, at everything that came through, and work out which way around should it be. Sometime people send messages saying it should be the other way around and that worked very well until 1986 or 87 and then there was a disaster. Czechoslovakia joined the internet. Czechoslovakia has the country code of .cs and when we got a .cs, I couldn't do it anymore; there was no way you could anymore guess which way route it should be. But among other things that were happening is that the DNS in the US, there was something called the network resource system, these are completely different. So I had to update both sets of tables every night so it will keep compatibility. Now the impact of that was the British could do what they like and still apparently be on the internet and that's what happened. So it's a rather long process. Finally they changed it in early 1990's.

I had told you that I had my governing committee and they insisted that I put access control and accounting in our network because they were worried that one part of such council will get paid too little compared to another part, so I had to do very careful accounting and because I have been given a free line one way to do some measurements for them; a 48 Kbits per second line was a lot for 1979-1980 (that was the analog version of the 64 Kbps digital line), so I had 48Kbps and 9.6Kbps one way with X.25 and then SATNET, which was 64Kbps and I could use them both ways. I had access control and accounting on, but I didn't particularly bother about it in the direction from the US to the UK and I put all the traffic one way so I didn't end up paying anything or paid the minimum and I put access control but I didn't have to pay. Then the governing committee, through the person from the post office said "look, he must have access control both ways" so I put access control on principle and I sent out a message to everybody who have passed through my system in the previous 3 or 6 months, saying that we had automatic log already and that in 2 or 3 months time we would apply access control; if you haven't registered and haven't got the right passed with whatever you are doing at the time, then your traffic would be blocked. And if I may use an expression, *that wind shifted the fan*; I suddenly got a hate email I have never had before; also it was for about 5.000 people; many others followed from other countries (even international communications were strictly not allowed by the time). Nobody had realized that topology was at that stage; we had no idea but nor did anybody else; nobody had the slightest idea; we knew who were going through, because we had weeks of logs, we could just look at them, even there was no reason to look at them. Remember that we were running a complete national service at any case. But this is in fact even more than national service because by that time there were also European connections



directly and nobody had any idea anymore who was going through what and they didn't even know they used emails; everybody thought they were living in a closed world, but they weren't.

- And by the way, that is one place Andreu where I must take exception with one thing you said in your public speech at the cold war secret bunker today. You talked about “switches” and then said, “Which we now call routers”. But of course, they are very different and the point was, we have proper gateways and that make a completely different communication system other side of gateways and that's what happened, that made a completely difference.

The genesis of the Gateways:

- The reason they were put initially was because although there were three different networks and you're right, packet radio, packet satellite and ARPANET, whenever one wanted to do any change in any type, and this is in 1973/74, the only people that would do the change (because they were running the old switches or IMPs) was BBN and every time one want to do it, one was told that there is a delay and it costs quite a lot to do it; **Bob Kahn** was very unhappy about that and the original reason that gateways were put in place, was in order to have key separation between the network part which ends at **Frank Heart** group, so release one from **the tube at** BBN. But another division of BBN got the contract to do gateways, so the monopoly stayed but the fact that it was a different group (with **Ginny Strazisar**) doing the gateway that make a huge difference and of course then in parallel, **Dave Mills** (from the University of Delaware) was doing it too (which were called Fuzzball¹³ routers).
- Fairly earlier on, I remember at those days international communications were simply not allowed. You weren't allowed to have switched telephones or other types and I remember early on, in 1975, the British Network I've talked about already had its leased lines including our center. I got a request from CERN, could we link to the ARPANET from CERN through you? So I had to ask my governing committee and my governing committee to the post office man, and of course, they said “no”. We then said we do not allow this but please tell us what you are doing to prevent this. The problem was that I was allowing anybody on that research network; it was a centralized research network. I was letting

¹³ Fuzzball routers were the first modern routers on the Internet. They were DEC LSI-11 computers loaded with router software written by David L. Mills (of the University of Delaware). The name "Fuzzball" was the colloquialism for Mills' routing software. About fifty of them were deployed worldwide in the early 1980s on the first 56kb/sec NSFnet (predecessor of the internet) to test many of the Internet's first protocols. A few are still active on the internet today.



everybody to go out except CERN to go through? How did I should stop CERN? What am I going to do to prevent it? So I wrote back: the following of the five methods they can get through with, I can prevent. The six methods that I can't prevent are the following; shall I put up a notice at CERN, saying you mustn't do XYZ, ABC because otherwise it would illegally go through to the US? They decided I shouldn't put up that notice. All of these took a lot of work, it's not for nothing because we started thinking very early on about access control and security and that was important. We got to be very heavily involved on that later of course.

“Incidentally, the German, Italian and Norwegians did not pursue a similar route. In the late 1970s, their growth of National Research networks was much slower, and quite divorced from any strong Internet links. Moreover, they had no equivalent of the UK Governing Committee, and never persuaded their Carriers to agree to the liberal interconnection policies adopted by the British Post Office and later British Telecom. For this reason it was not possible for a significant academic involvement from those countries with their US colleagues, until USENET, EARN and other similar Internet developments took off in the middle 1980s”. [Excerpt from Ref #2]

What do you think about the future of the Internet?

The first think, I am very interested on watching internet's impact on areas it hasn't gone to before, where the impact is huge. I get amused to some sense that history is repeating itself. The problems we had in the 1970's and early 1980's in getting things accepted in UK and Norway Europe then have to be played through again in the late 1980's and 1990's in the rest of Europe and Japan and some other countries. And in 2006 having to be played through yet again in many other countries I deal with. Problems are that we need to support these things, particularly research communities; we just have done a short report on the status of funding and services in the newly independent states in Central Asia and the Caucasus and virtually none of them have state funding for their research networks. We are putting in money from NATO and UNDP and a few other people but there is no national funding yet. They still don't realize its importance; the same happens of course in Africa.

When IP_{v6} does come in properly, it will have an immense impact; sooner or later it will do something even about the address shortage going on in several places; that will have a major impact on services you have to use.

Speed, it is obvious that everything is going up. I see very clearly that the battle to have all real time services (voice, video et al) going over IP has been pretty well won. What impact it is going to have on the whole communication perspective of the companies, is not clear yet.



There's more than that, the battle of circuit switch telephone exchanges is over too; circuit switching will disappear in the short - medium term and for the long term its over but the impact that it has on the finances of the whole telecommunication industry is not over yet and that should be a very difficult interest in one which to watch. But, it all went very well for *Skype*¹⁴ to say that this thing is free but that implied that there's new infrastructure and how that infrastructure is going to be maintained under this, is not clear. The whole question of convergence and whether or not the mobile industry will change to a more open, less proprietary environment, is still not clear.

There's a lot of re-arrangement and many things happen in the telecom industry but it is already all related to the internet.

Do you see any technological trends?

¹⁴ skype: is a software application that allows users to make voice calls over the Internet. Calls to other users of the service and, in some countries, to free-of-charge numbers, are free, while calls to other landlines and mobile phones can be made for a fee. Skype was written by Estonia-based developers Ahti Heinla, Priit Kasesalu and Jaan Tallinn, who had also developed the file sharing P2P software called Kazaa.



Well, obviously fiber yes, fast switches yes, I think satellite will continue in the parts of the world I deal with; it's quite clear that fiber will take over in principal places and cities but if you look at geography or topography of central Asia, there's no chance that fiber would go through all the places. So the strategy we have is we are putting in satellite now, we expect to be able to put in fiber to the main capitals within the next 2 or 3 years, and then we'll move the earth stations more to the remote regions of the countries; I think that's what is going to happen. It's a NATO effort, it's my job to do a little bit of deal making so NATO is paying for the main part of communications, and I have persuaded the European commission to pay for the management of a NATO project, which I think it's the first time it ever happened. I persuaded *Cisco* to donate a local area network in every country, nine countries to go between the earth



station and the national research network and then we got a little bit of money from ISOC and a little bit of money from various others. But we are going to get some probably from the Agakhan because of the university in Central Asia, in the mountains, the World Bank is interested in doing video conferencing in some of the remote places, we put a video conferencing system in each of the countries and we are now working with the desktop conferencing. These are the things that we used to do 20 years earlier.

October 30th 2006. Peter Kirstein and the author during the interview at the Kelvedon Hatch secret nuclear bunker.

Lessons learned



"A key factor in the early start of the project was that a small number of key people could make individual decisions and investments for a speculative project, in a way that was quite impractical for larger committees.

Second was the lucky chance that Government intervention, in the form of the Customs and Excise, forced the project to remain in private hands in the UK; if it had been under a Government Agency, it would surely have been killed at some vital juncture in its first decade.

As an example of the danger, I was requested by one Agency in the late 1970s to stop working on the Internet Protocols and work exclusively on International Standard ones; needless to say, I refused. In private hands, even when the going was rough from one source, another could be mobilized". [Excerpt from Ref #2]

ADDITIONAL READING

PAPERS & BOOKS MENTIONED / RECOMMENDED

- [1] Vinton G.Cerf, Peter Kirstein, "*Issues in packet-network interconnection*" *Proceedings of the IEEE*, pp. 1386-1408, November 1978.
- [2] Peter T. Kirstein, "*Early Experiences with the ARPANET and INTERNET in the UK*", Department of Computer Science, University College London, 1998.
- [3] Peter T. Kirstein, "*The early history of packet switching in the UK*", *IEEE Communications Magazine*, Vol. 47, no. 2, February 2009 , pp. 18-26